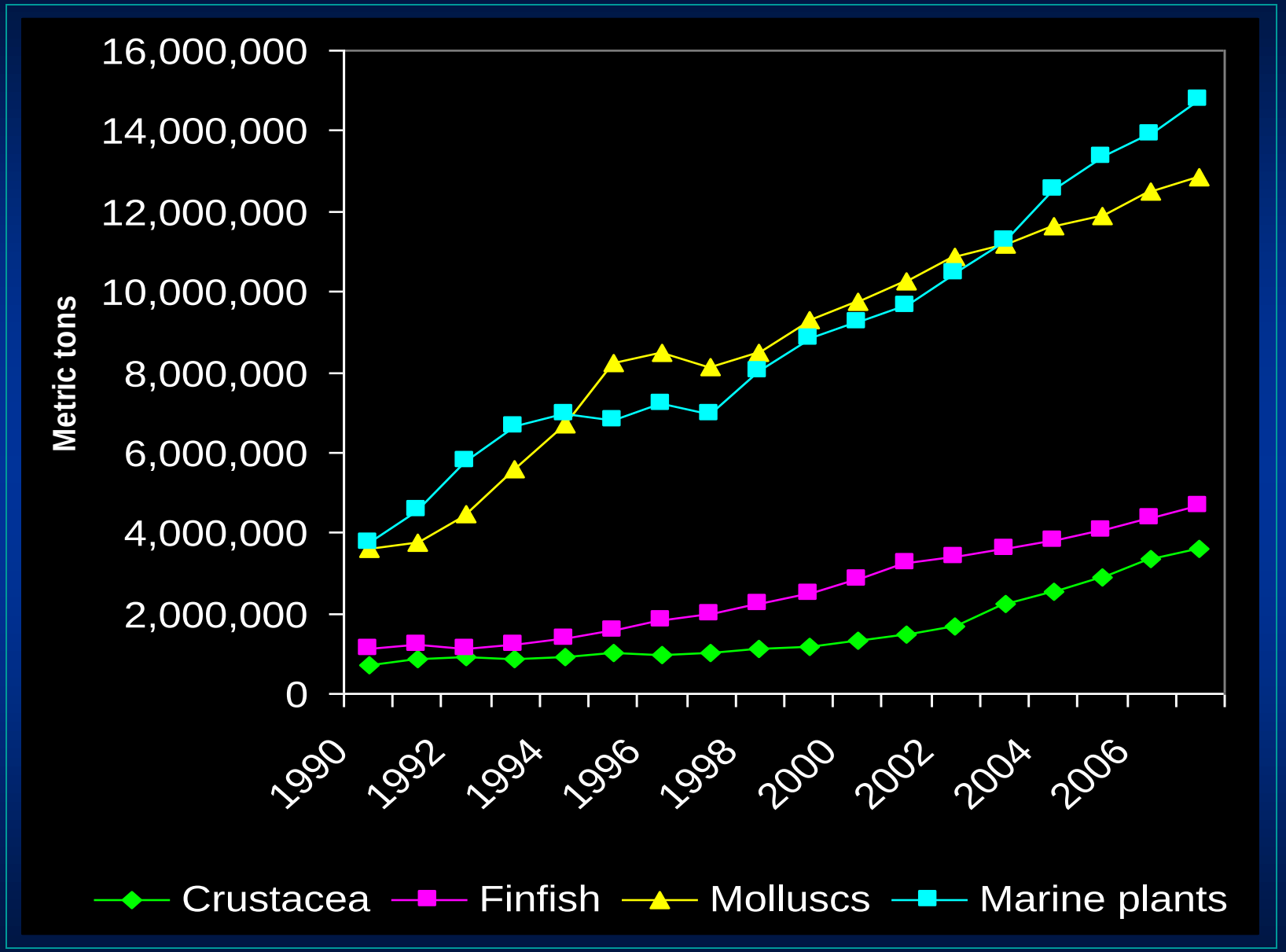
The Potential for Seaweed Culture to Provide Useful Products and Ecosystem Services

Kelp Farming in China

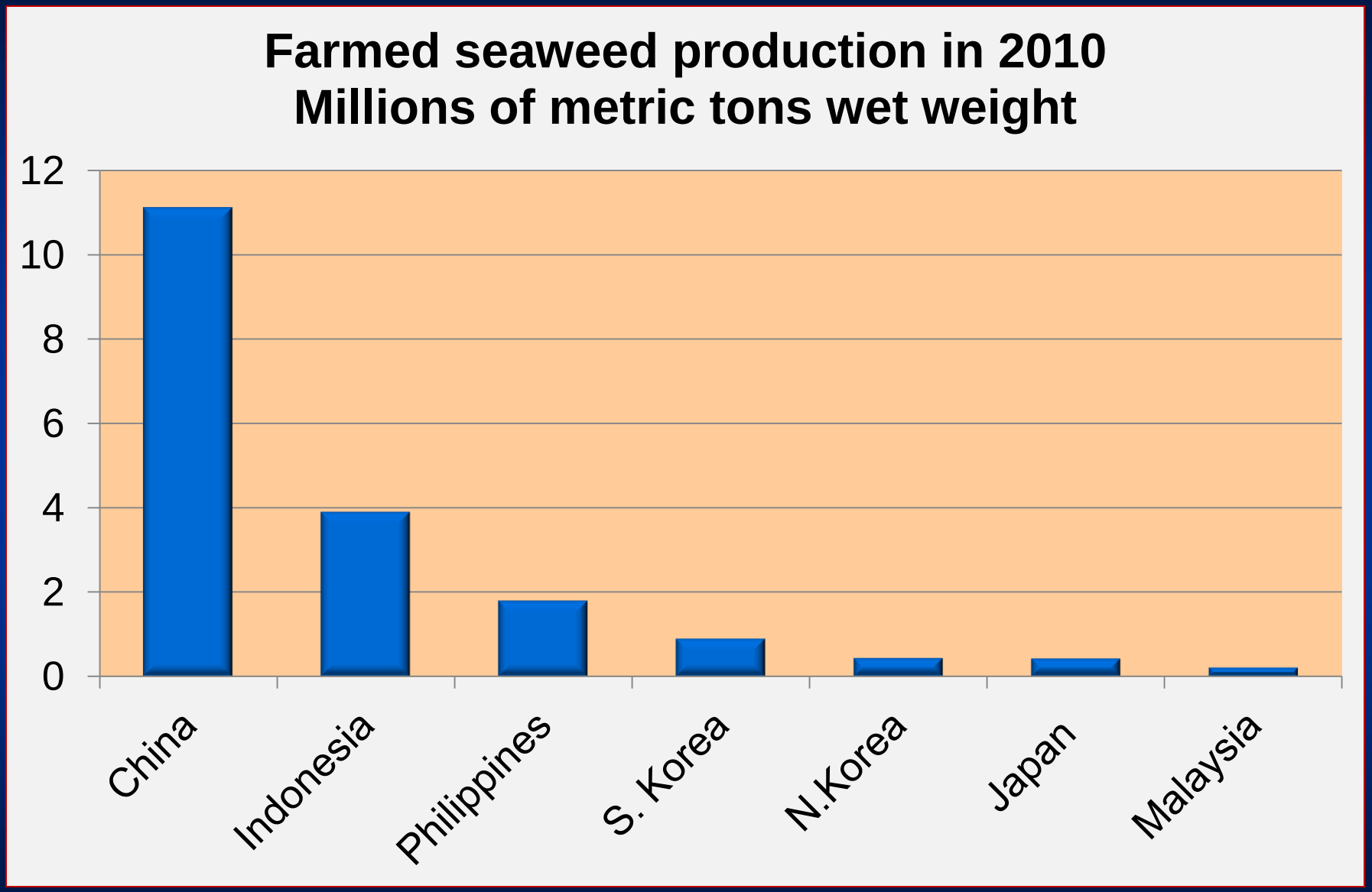
photo courtesy Chen Jiaxin

World production farmed seaweed in 2010 – **19 mmt**



Source FAO

99.4% from seven countries in Asia



Source FAO

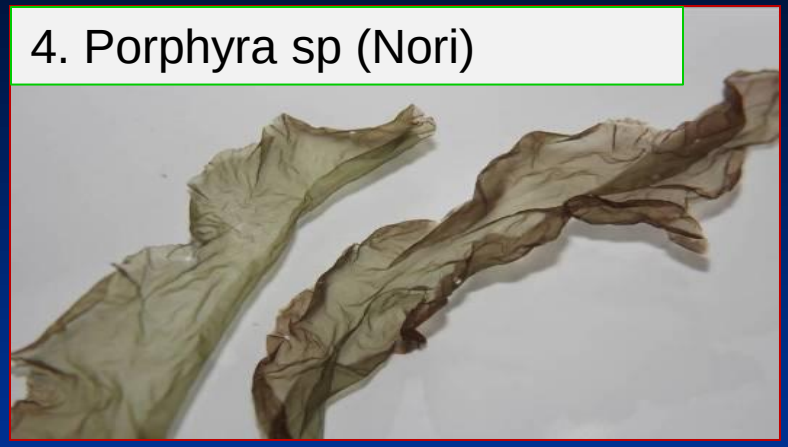
Six main species (Photos 1-5 courtesy Prof. Chen Jiaxin)

1. Laminaria japonica (Kombu)

2.Undaria sp (Wakame)

3. Hizikia (Sargassum) fusiforme

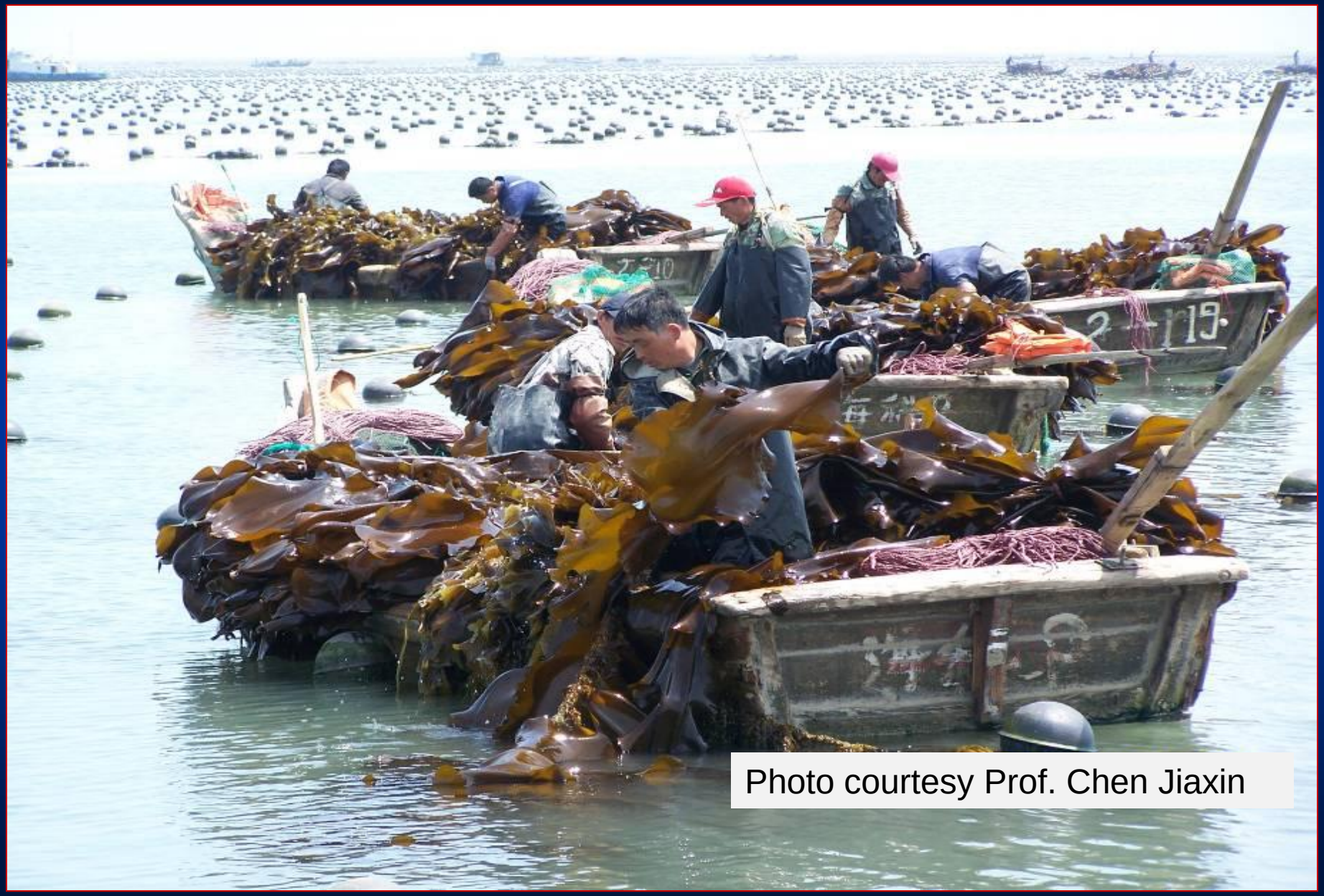
4. Porphyra sp (Nori)



5. Gracilaria lemaeiformis

6. Kappaphycus sp

Laminaria japonica (Kombu) farm - China



Porphyra (nori) farm in Jiangsu Province, China

Photo courtesy Prof. Chen Jiaxin

Undaria (Wakame) farming in Dhalian, China

Photo courtesy Prof. Chen Jiaxin

Eucheuma farm in Zanzibar

Most important use is FOOD > 70%

Wakame salad

Photo - www.diytrade.com

Seaweed noodles

Photo Prof. Chen Jiaxin

Nori

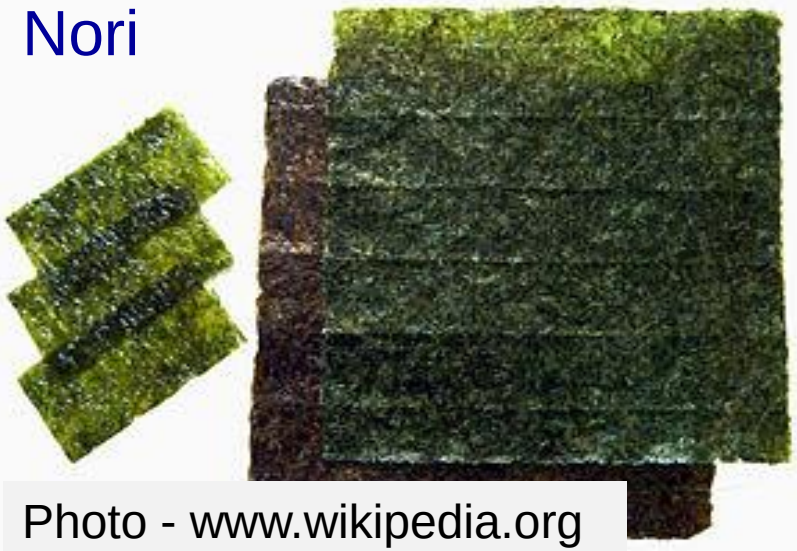


Photo - www.wikipedia.org

Seaweed soup

Photo - www.nobcook.com

Ocean Approved Inc - Maine

www.oceanapproved.com

- Wild harvest & now farming kelp *Saccharina latissima* for
- Kelp noodles, salad & slaw cut.

"Kelp waits to take its place in America's stomachs"

Going Green on msnbc.com

Other useful products – seaweed composition

Composition varies with species, time of year & conditions

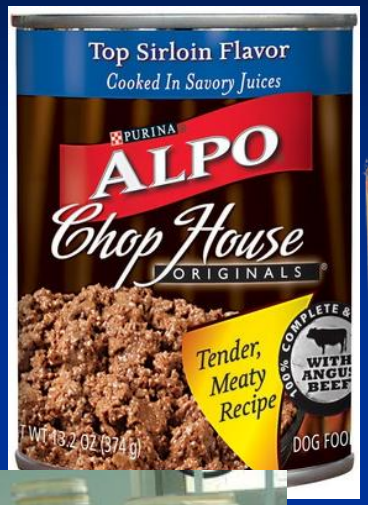
- Water 75 -90 %

% dry wt

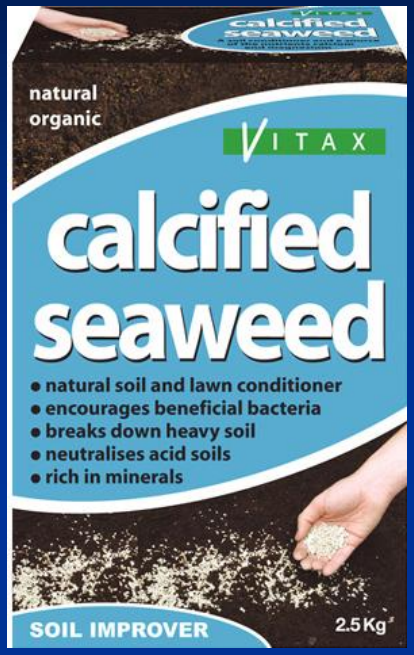
- Carbohydrates (polysaccharides – structural & storage) alginates, agar, carrageenan, mannitol. 30 - 60
- Proteins (digestibility inhibited by polysaccharides). 5-15
- Lipids – (mostly polyunsat. fatty acids, ω 3 & ω6). 1-5
- Minerals (Ash – calcium, potassium, iodine). 15-30
- Carotenoids & vitamins Yes

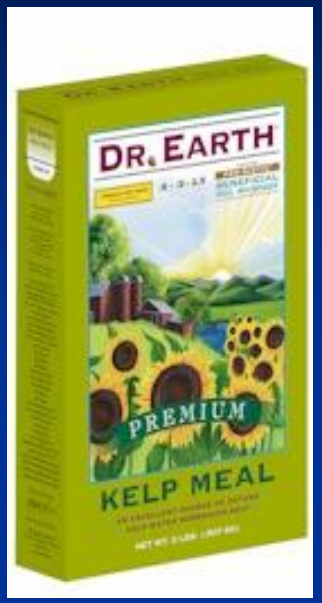
In most cases all the biomass is usable

Marine Hydrocolloids : Alginate, Carrageenan, Agar – use 15 – 20% world seaweed production



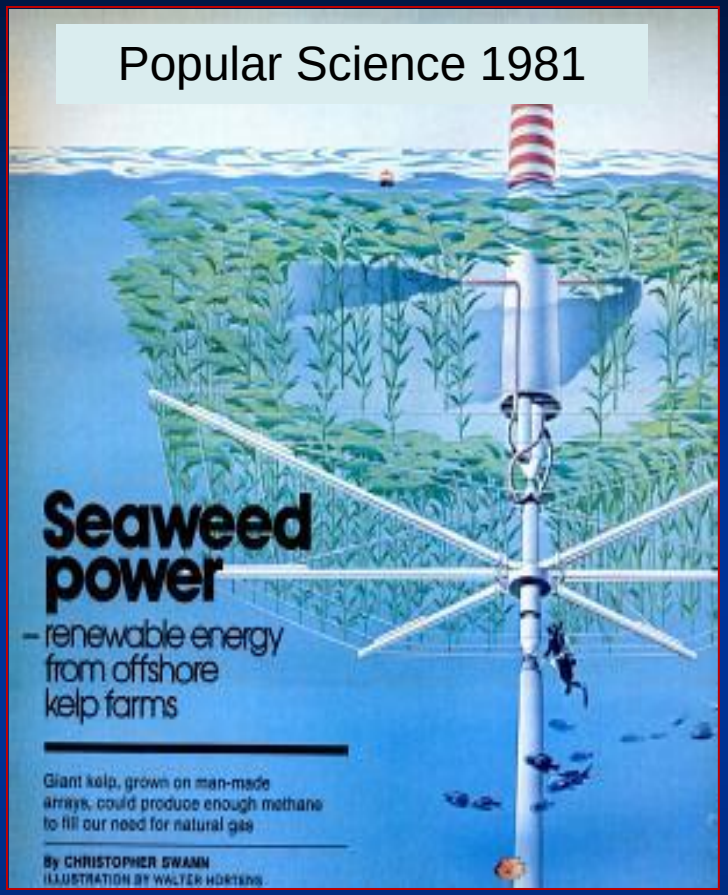
Other products and byproducts : soil conditioners, fertilizer, feed, medical, nutraceuticals, paper

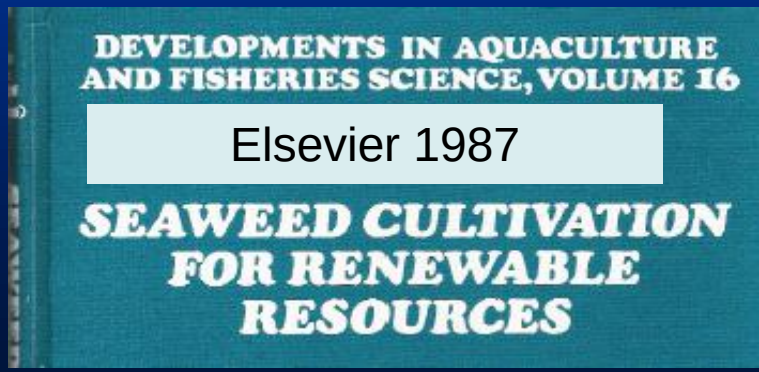




Bio-energy – Ocean Food & Energy Farms

- Proposed by North & Wilcox 1968 and led to:
- US Marine Biomass Program ‘72 – 81 – which lapsed because:
- Early in the technology
- Need for very large volumes
- Byproducts undervalued
- ‘70s oil crisis came to an end





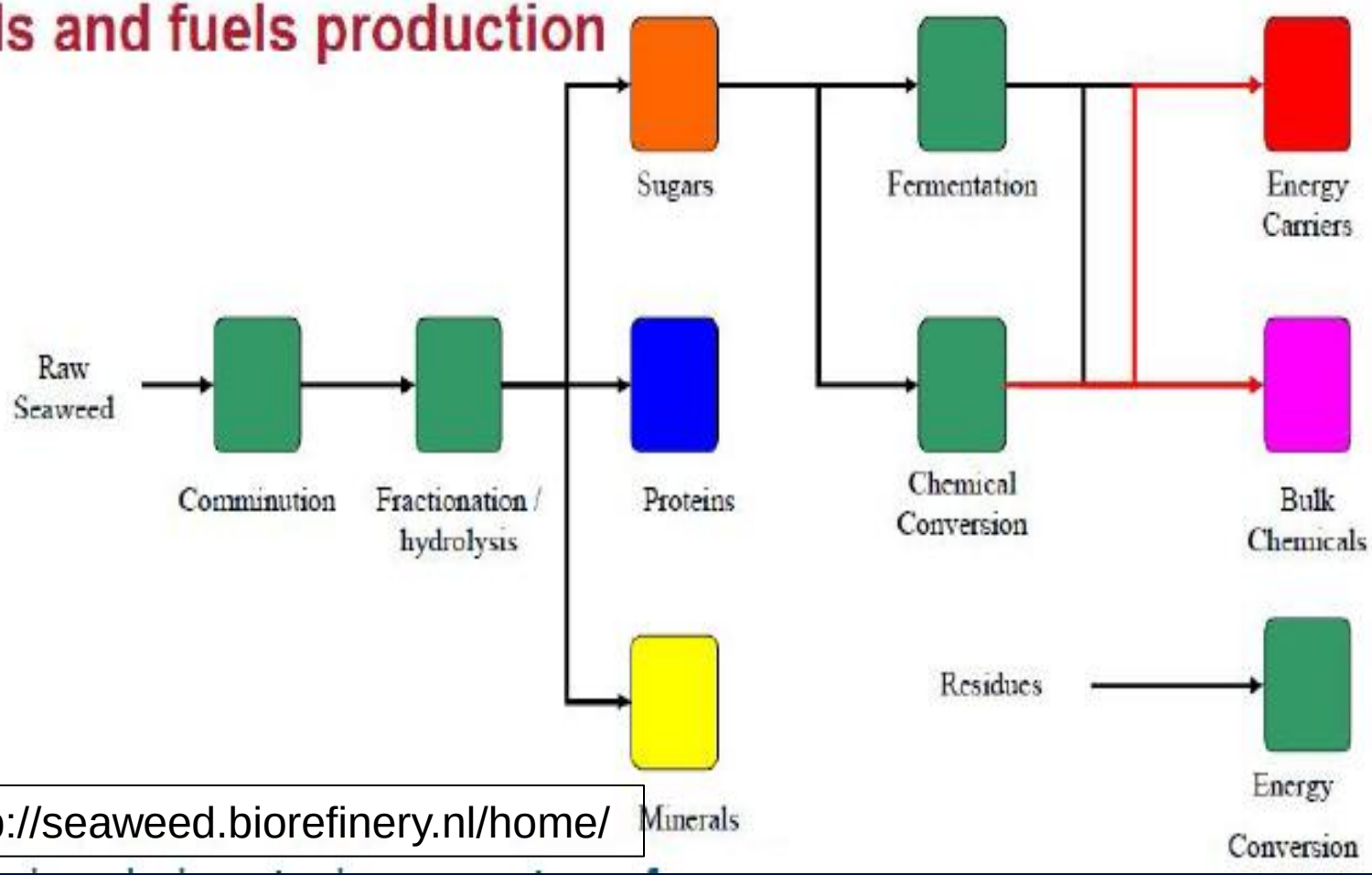
Biofuels now in favor again

- Microalgae > biodiesel
- Macroalgae > methane by biodigestion
- Ethanol and butanol by fractionation of fermentable sugars
- Potential for fuel / feed co-products – especially aquaculture feeds.

Energy Research Center Netherlands

Seaweed Biorefinery project

Aim: Development of biorefinery technologies for chemicals and fuels production

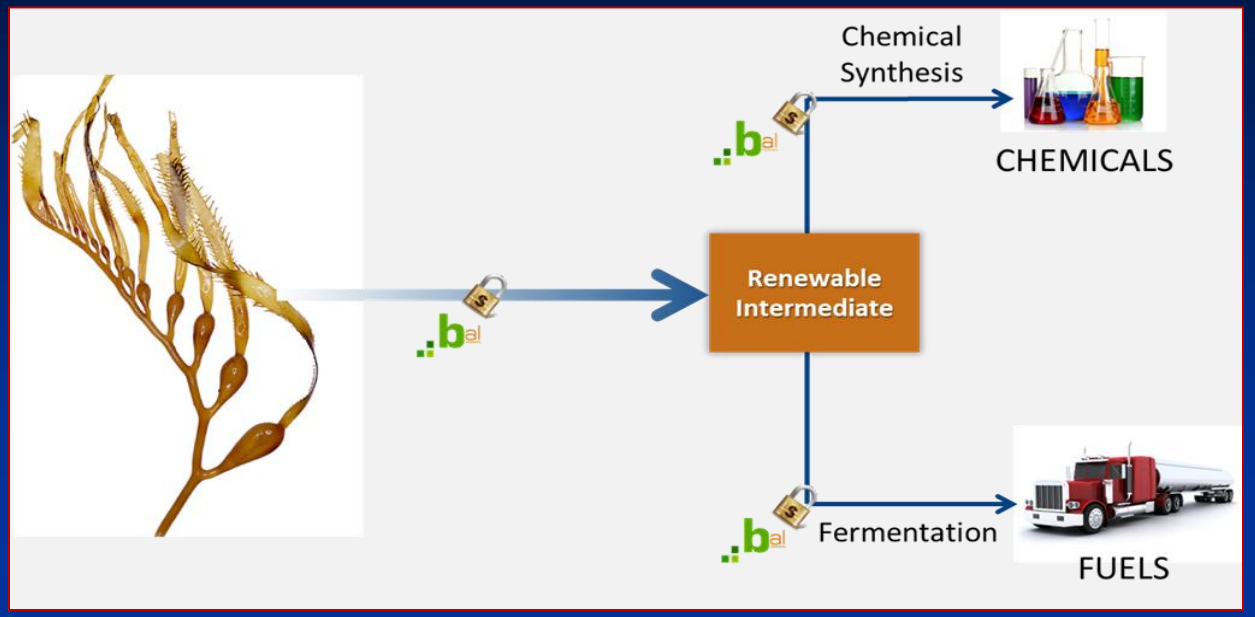


Source: http://seaweed.biorefinery.nl/home/

Bio Architecture Lab www.ba-lab.com

- GMO microbial (*E. coli)* digestion of seaweeds to 'renewable intermediaries'

(Wargacki - Science 335, p308 Jan. 2012)



Other biofuel projects

Biomara, EU

European Union
European Regional Development Fund
Investing in your future

A project supported by the INTERREG IVA Programme

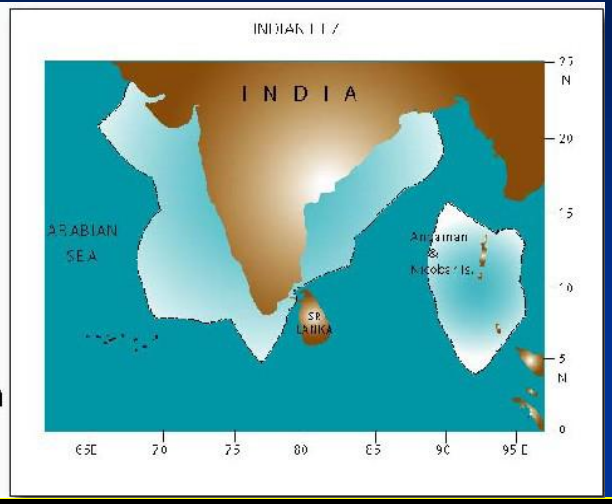
Highlands & Islands ENTERPRISE
Northern Ireland Executive
The Scottish Government
THE CROWN ESTATE

Sintef, Norway

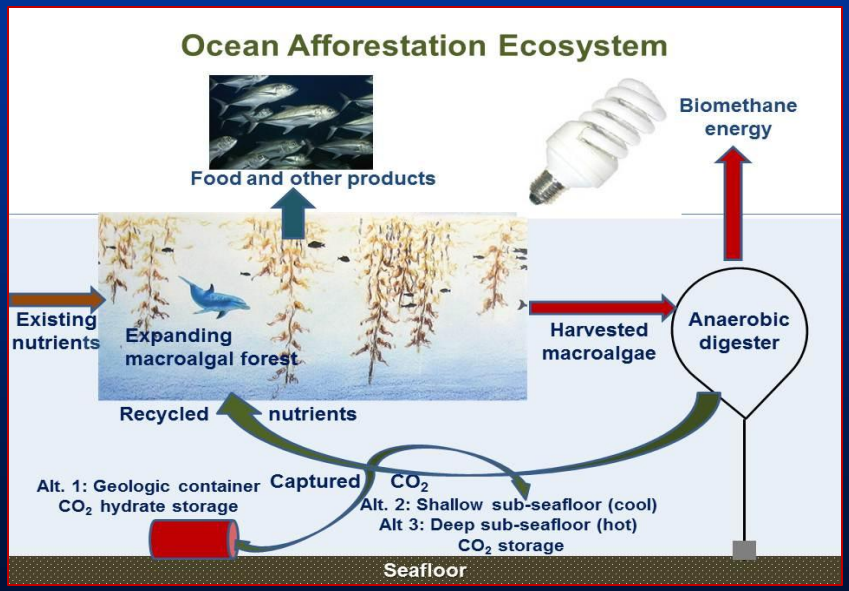
Current Status of Biofuel Production Technologies

Technology	Laboratory	Pilot plant	Demonstration plant	Market
Sugar/starch ethanol	→	→	→	→
Biodiesel - esters	→	→	→	→
Lignocellulosic ethanol	→	→	⇢	
Biobutanol	→	→		
Algae biodiesel – lipids to esters	→			

Sea6 Energy, India

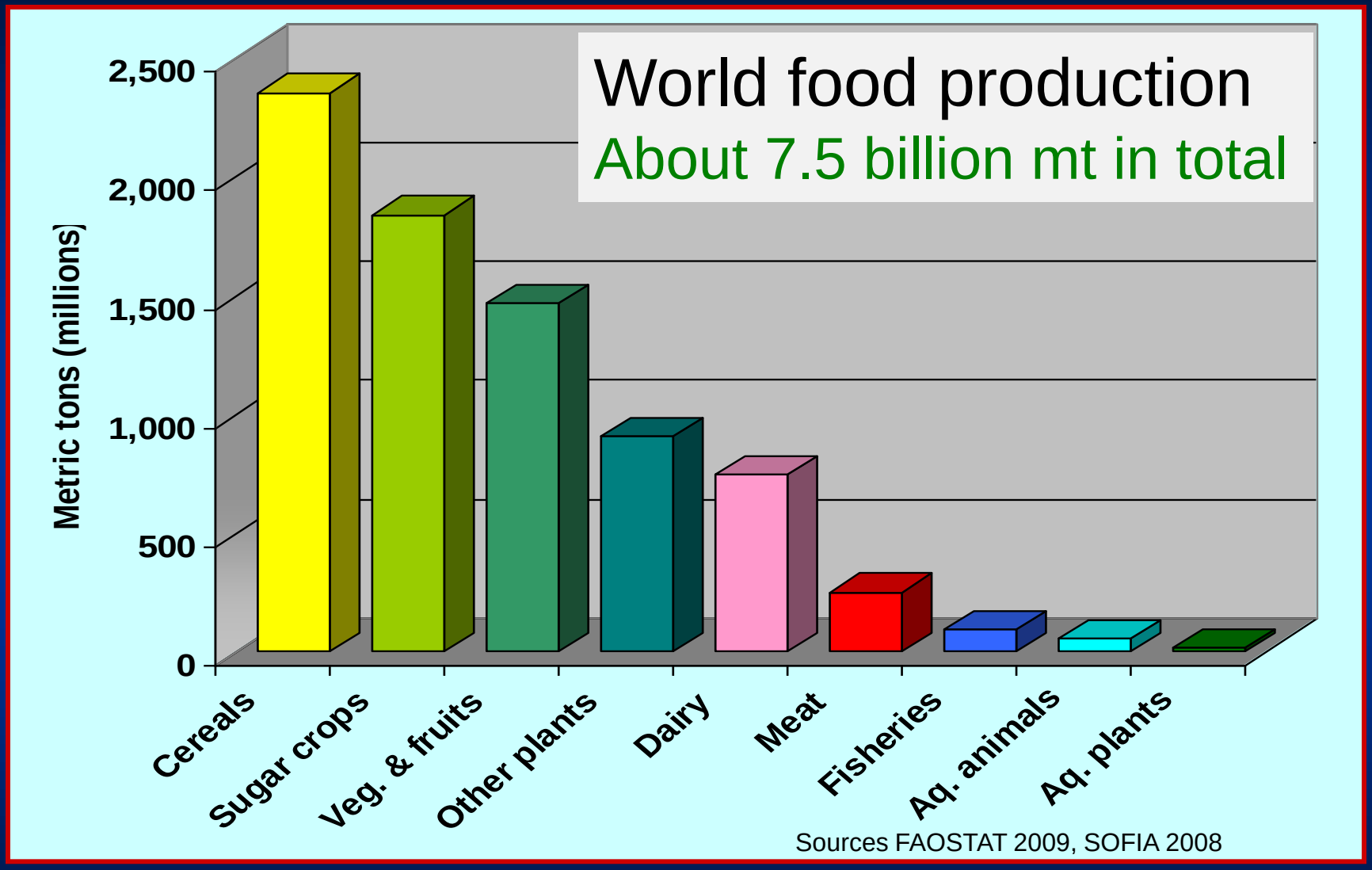


PODenergy USA



ECN Netherlands

A need for perspective



FAO says we need 70% (5 billion mt) more by 2050

We make very poor use of the sea

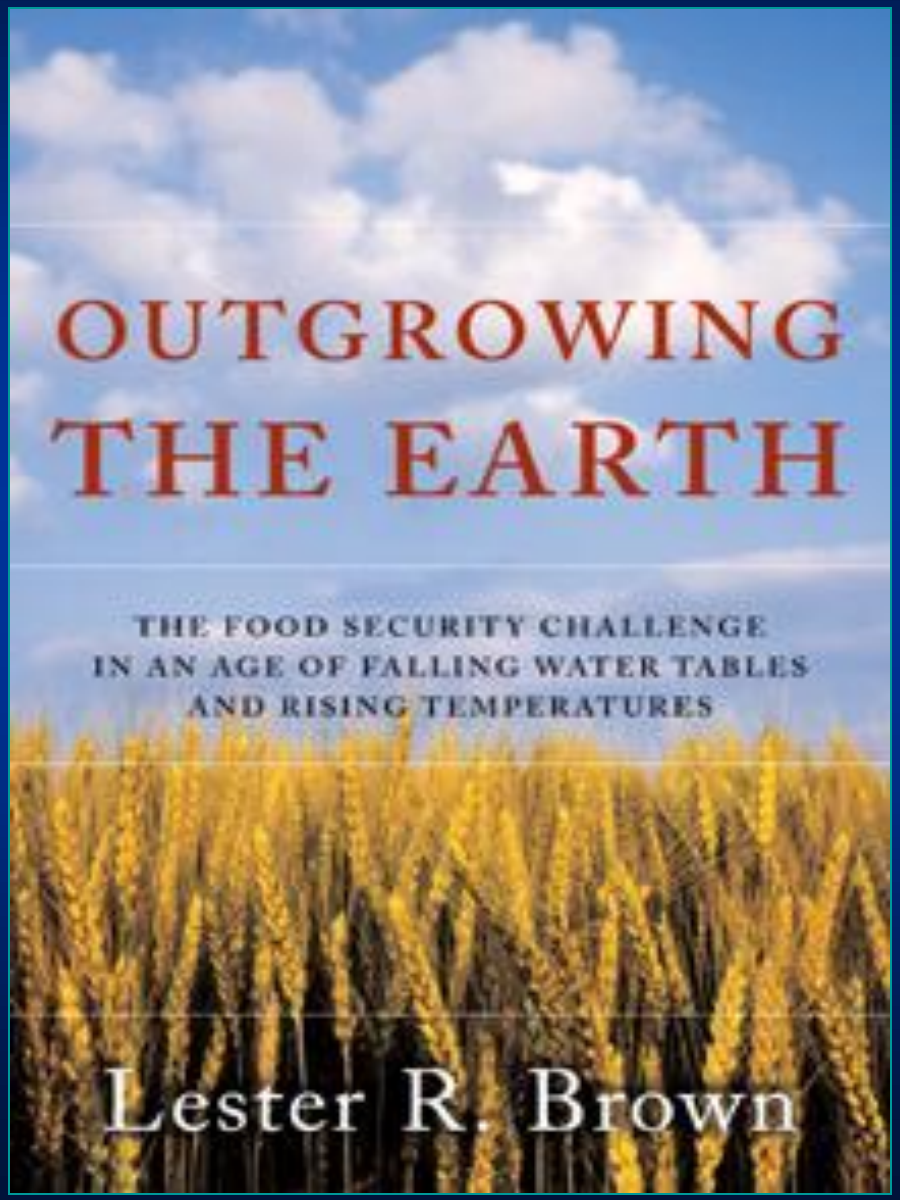
The oceans cover 70% of Earth but yield only 120 million mt (1.5%) of our food.

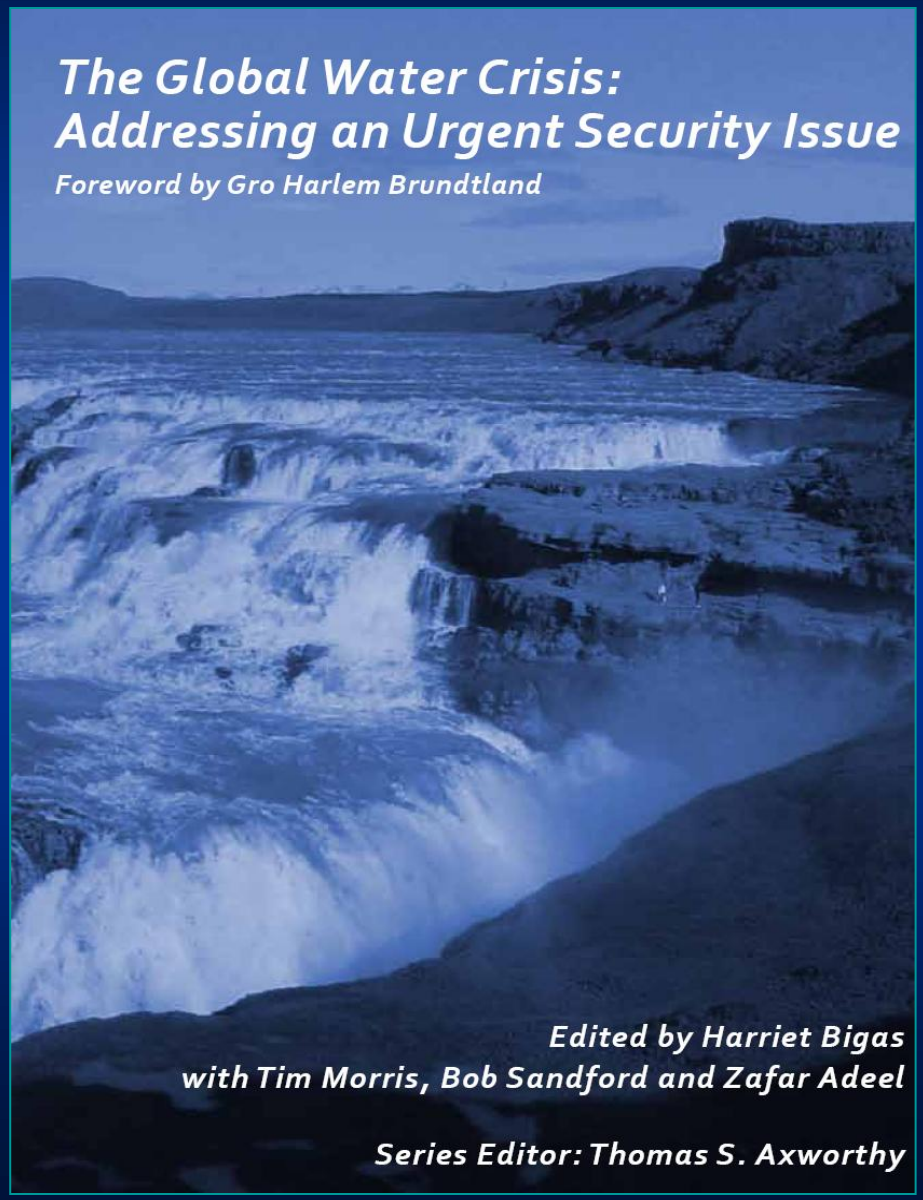
Yield per hectare / day

	Marine	Freshwater	Terrestrial
Protein (g)	0.5	8.8	32
Calories	3.3	54	1,251
Total wt (g)	9.3	88	1,384

Source FAO STAT 2003 & Millennium Ecosystem Assessment

Does that make sense? Do we need to do something about it? If so – what?



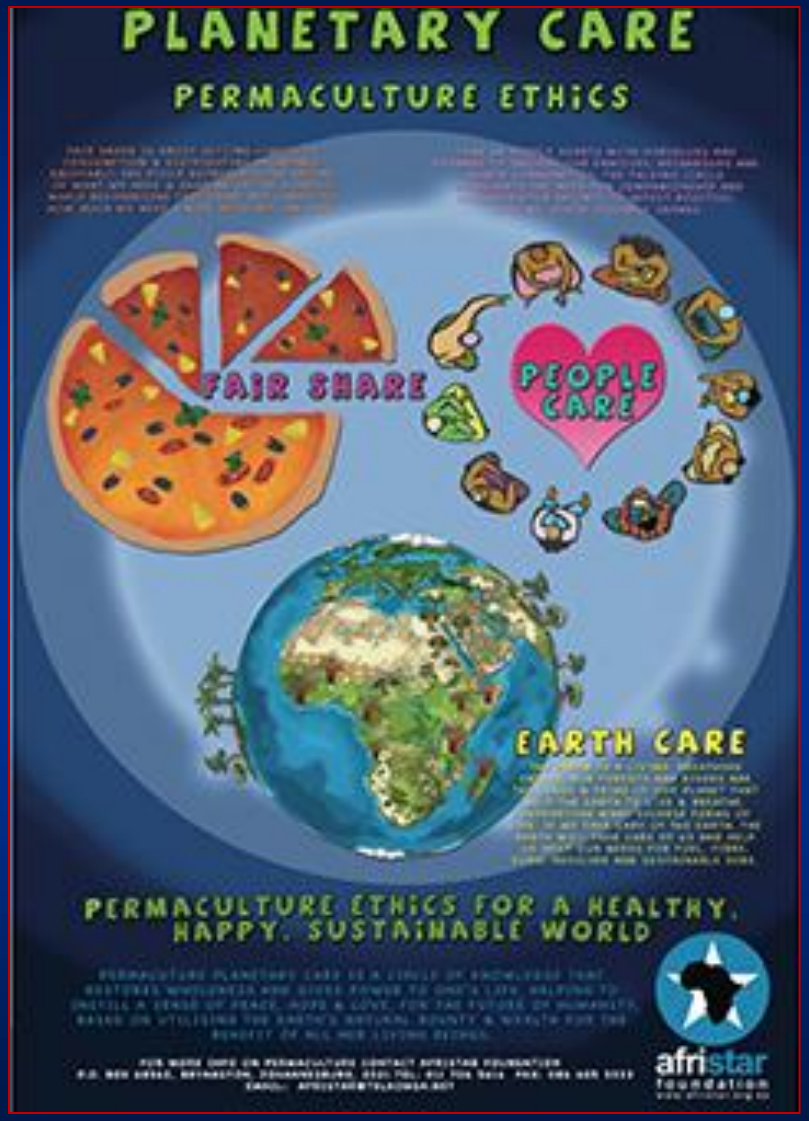


Based on what we've learned in marine aquaculture

- Could we now develop a 'Marine Agronomy' to produce raw materials for food, feed and fuel as agriculture does today?

What could it do for us? How would we value it?

- How much food, feed and fuel might it produce?
- What might be the ecosystem costs / benefits?
- What might be the economic benefits in terms of jobs and wealth creation?
- What value would they have, not only today but 25 or 50 years from now?



afristarfoundation.org

Imagine a global industry that by 2050 produced

- 500 million mt dry wt seaweed /yr (2x US corn production).
- 6.7% of present world food prod^{n}
- 170 x present seaweed prod^{n} needs 14% annual growth.
- 10% of the additional food that FAO says we will need.
- Would create jobs for millions of people*

*One billion employed in world agriculture today (FAO)

It would also

- Spare at least 50 million hectares from land clearance.
- But would use similar area at sea : 0.3% of oceans' surface
- Spare 500 km^3 freshwater / yr (5.5% of FW used by all Ag.)
- Produce about 50 mmt algal protein and 10 mmt algal oil.
- 40 billion gallons of ethanol (3 x present US $prod^n$).

And it would

- Extract 8 million mt N/yr : 14% ann. fertilizer run off.
- Use 135 million mt carbon/yr: 6% annual ocean uptake.
- Be unaffected by drought or air temperature.
- Create habitat
- Need no soil cultivation

Nutrient Bioextraction

Graphic & images courtesy Prof. Charles Yarish (U. Conn.)

Long Island Sound

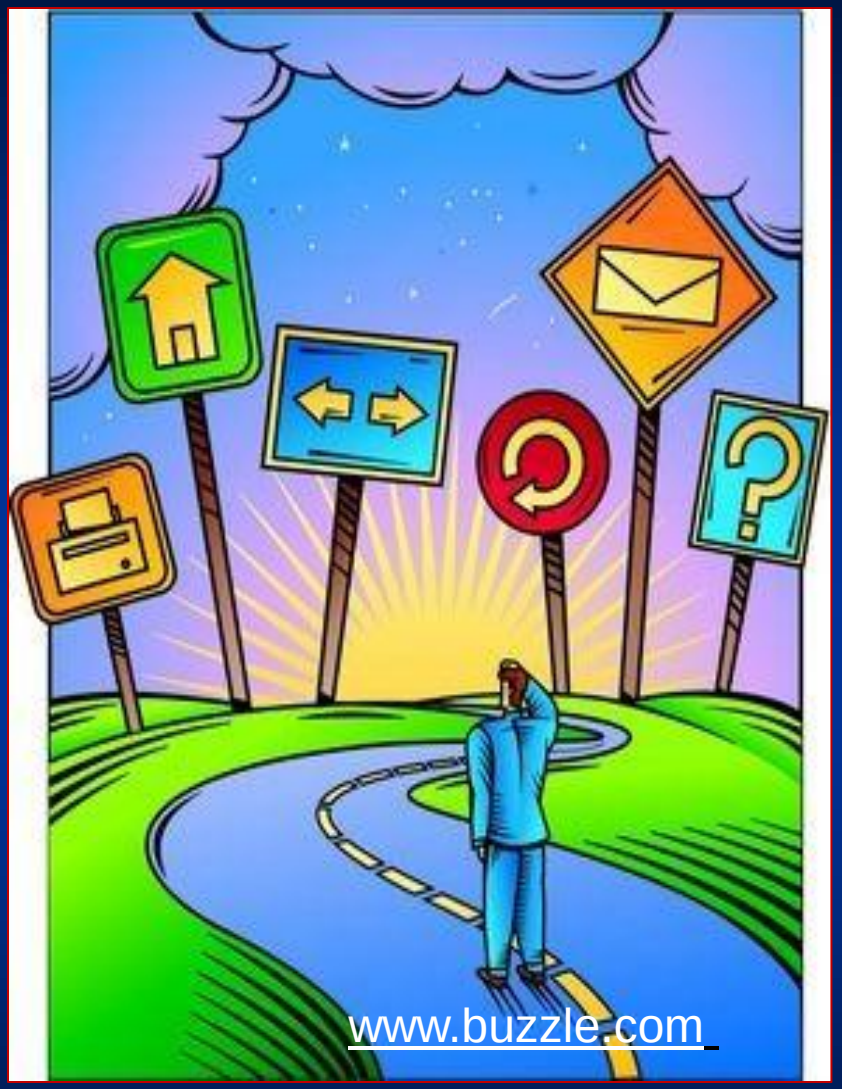
Bronx NY

But *"Expansion of seaweed farming is not a panacea"*

"It needs ecological approaches to development and an enlightened governance system to be an important solution to global food security" Barry A. Costa-Pierce ecologicalaquaculture.org

No easy solutions to any of our global challenges?

- Climate change?
- Falling water tables?
- World food security?



All involve tough choices & no reason not to begin?

And doing nothing is not an option

Can we make more productive use of the sea?

If so, should we try?